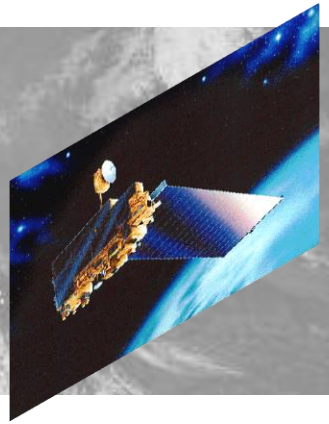
# Evaluation of the Sensitivity of the Amazonian Diurnal Cycle to Convective Intensity in Reanalyses



**Kyle Itterly, Patrick Taylor, and Brant Dodson**

**CERES Science Team Meeting**

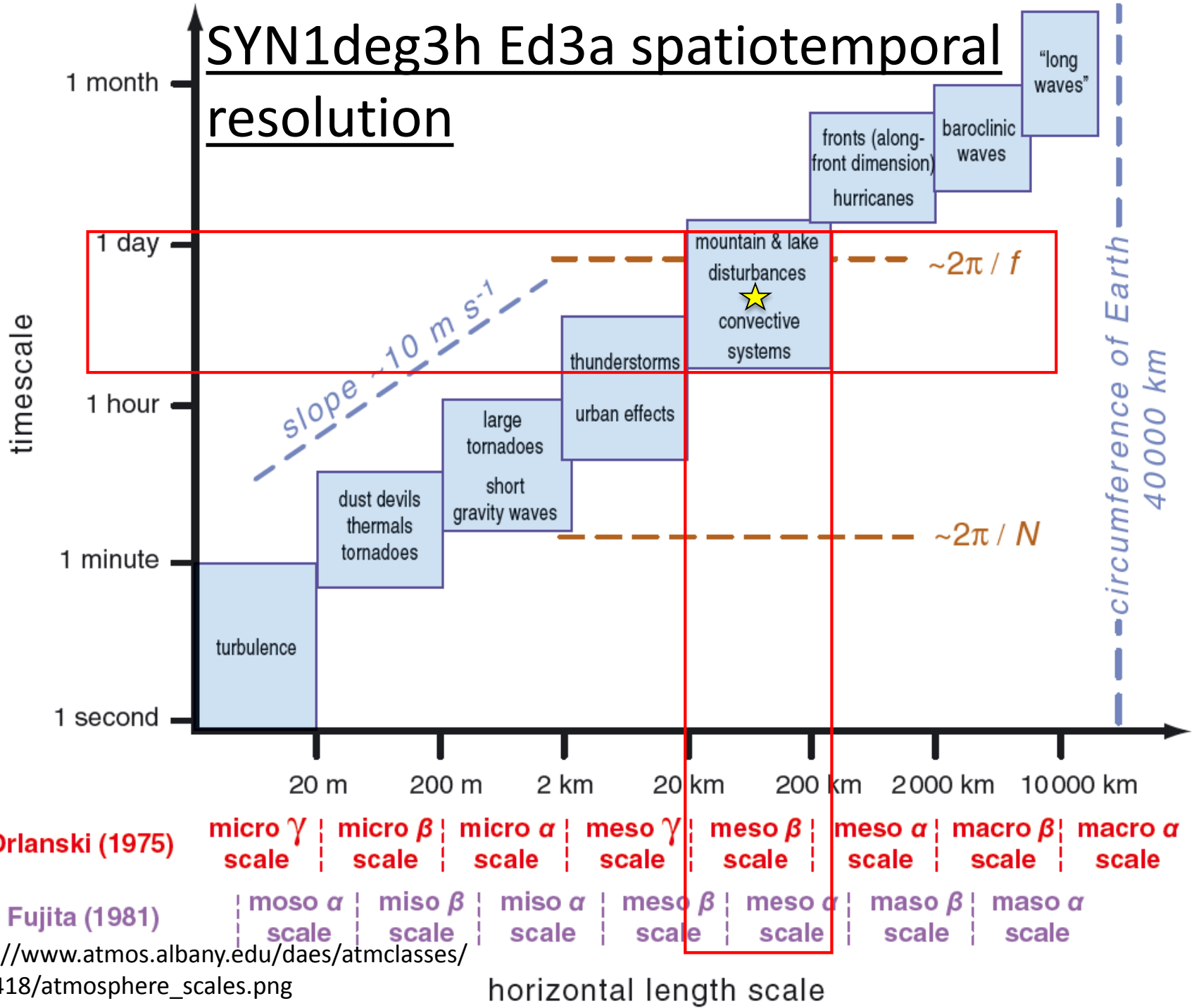
**May 18th, 2017**

1) **Define convective intensity regimes and method**

2) Evaluate diurnal cycle shapes by regime

3) Regress diurnal cycle against atmospheric state by regime

# SYN1deg3h Ed3a spatiotemporal resolution




http://www.atmos.albany.edu/daes/atmclasses/atm418/atmosphere_scales.png

# 3 methods to evaluate models

1) Use full climatology for all

- ✓ Continuity in water cycle and energy budget calculations
- ✓ No systematic bias from selection
- x Different distribution of convective regimes
- x Compensating errors can mask subtler issues in models

2) Pick individual case studies

- ✓ Field campaigns
- ✓ Attribution of biases to specific features
- x Limited verification data
- x Resolution not sufficient to resolve certain scales of processes

**3) Composite "best days" where models and obs. meet certain criteria**

- ✓ Model parameterizations receive similar forcings (data assimilation)
- ✓ Interpretation of processes possible with conceptual model
- x Some original model biases still present
- x Possible systematic biases introduced (sensitivity tests)

# Diurnal and atmospheric state variables

DC "process" == 06:00 – 06:00 LT

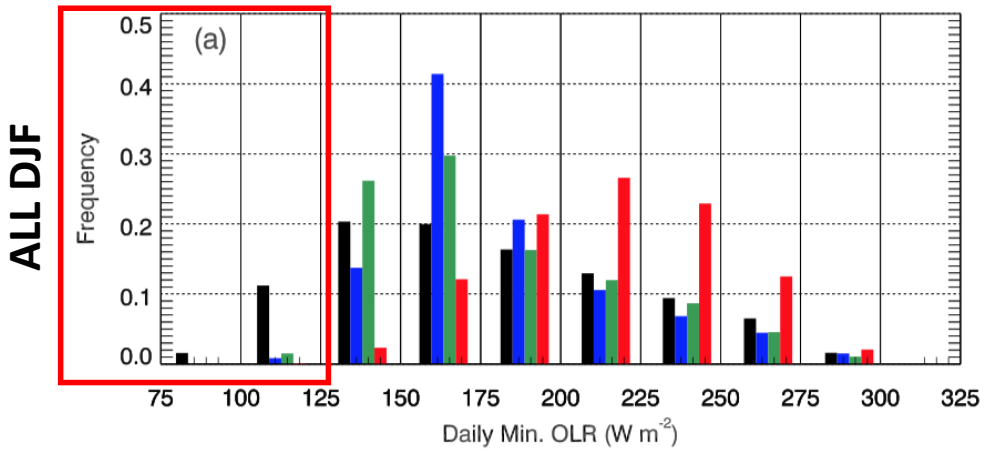
- Diurnal Cycle (DC) Variables (**DCVs**)
  - Daily, **3-hourly** TOA Fluxes, Clouds, and Precipitation
  - **Obs.** (CERES SYN1deg/TRMM), MERRA-2, MERRA, ERA
  - Amazon wet season (DJF) 2002-2012
  - $LWCF = OLR_{CLR} - OLR$
- Atmospheric State Variables (**ASVs**) from models
  - Daily-averaged standard anomalies
  - Convective Available Potential Energy (CAPE)
  - Upper Tropospheric Humidity (UTH)

$$UTH'_{STD,VCON} = \frac{(UTH_{VCON} - \overline{UTH})}{\sigma(UTH)}$$

[Taylor, 2014; Dodson and Taylor, 2016]

# Convective intensity classification

**All reanalyses miss extreme convection**



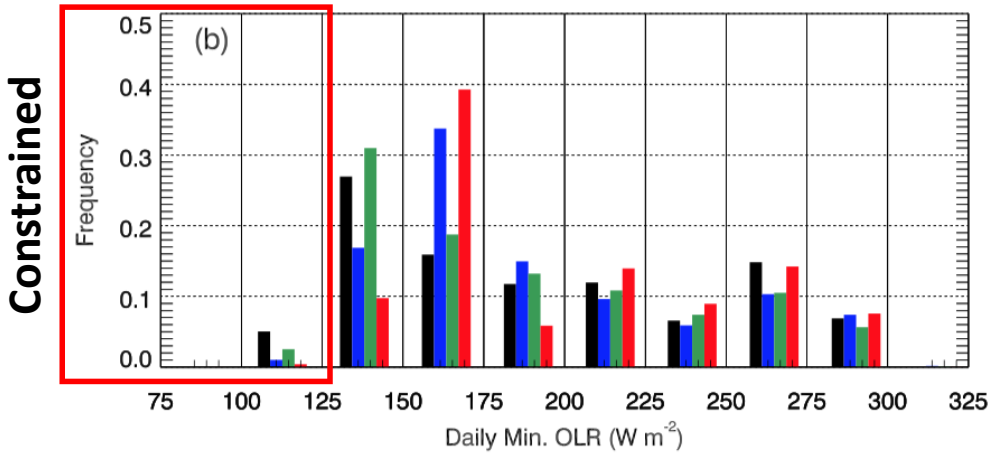

**Daily Minimum OLR Bins (W $m^{-2}$)**

| VCON | CON | STA | ALL |
|---|---|---|---|
| [<175 | 175-235 | >235 | All ] |

- Proxy for convective intensity
- Focus on VCON and ALL

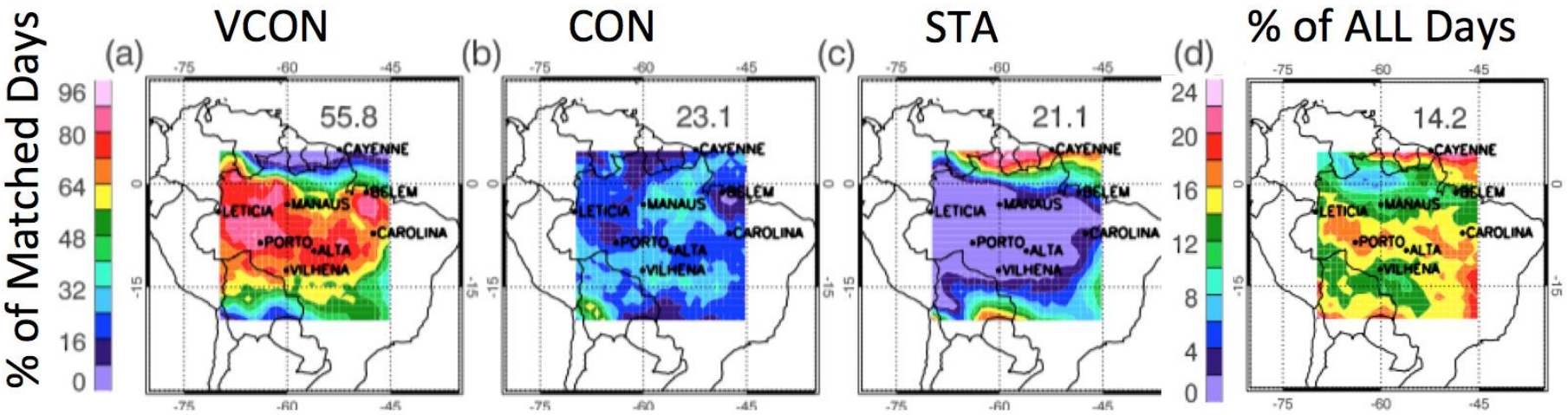
CERES/TRMM MERRA-2 MERRA ERA

**Better**



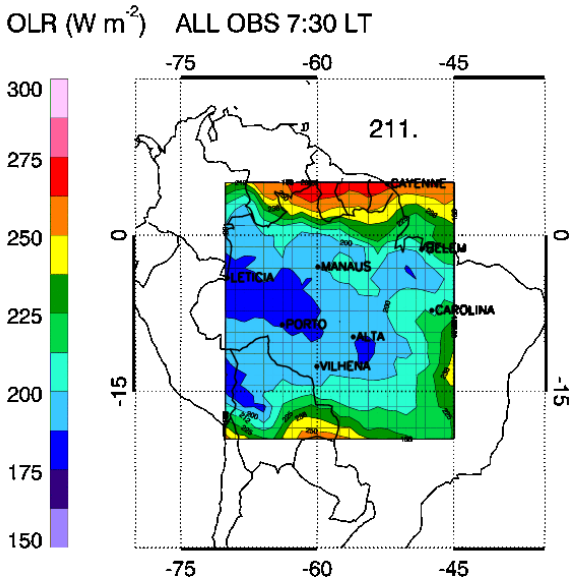

- **Days only included if CERES and all models agree on regime**
  - Population of days equal
  - Discuss sensitivity to criteria

# Spatial distribution of regimes

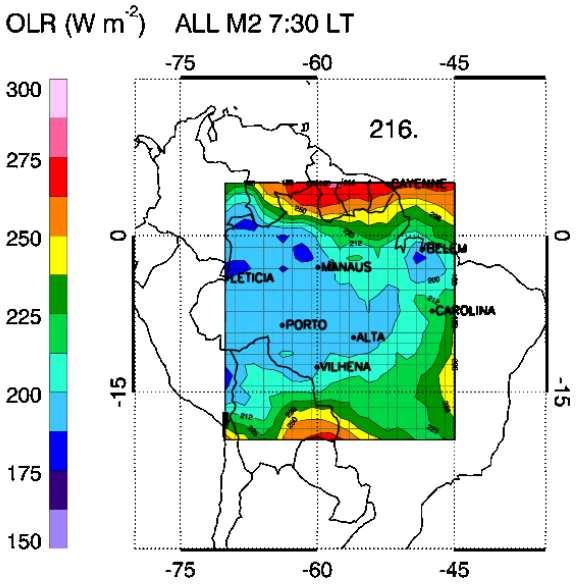



- VCON regime focuses on Amazonian interior
- CON regime captures propagating features related to orography and squall line
- STA regime occurs mainly around extreme edges

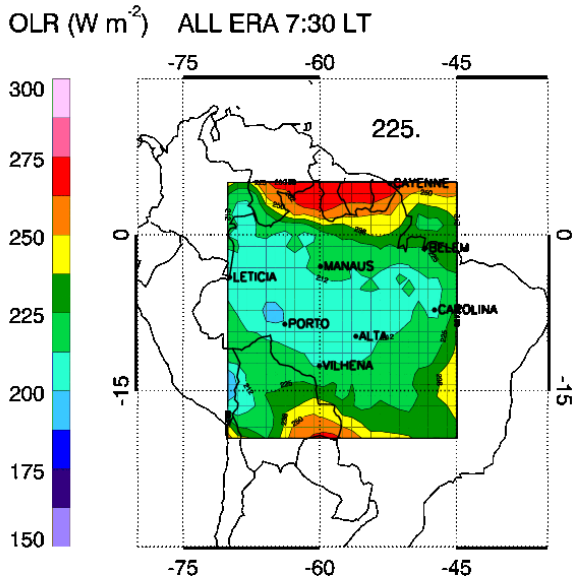
## Constrained CERES



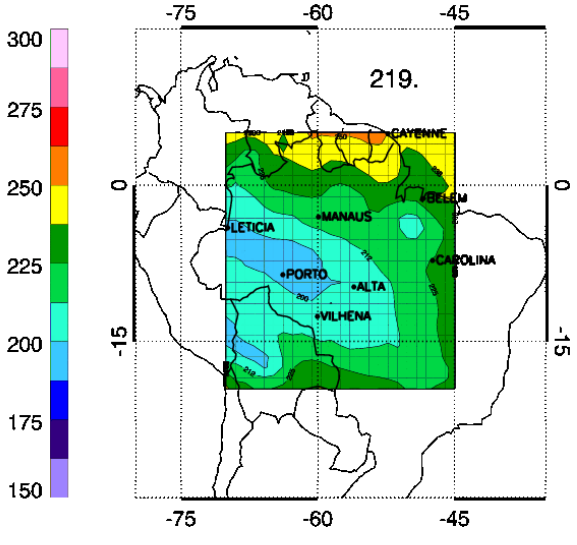

## Constrained MERRA-2




## Constrained ERA




## All DJF days CERES

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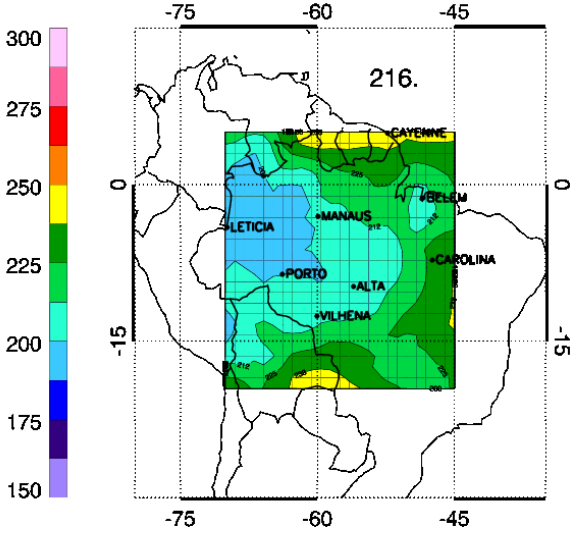
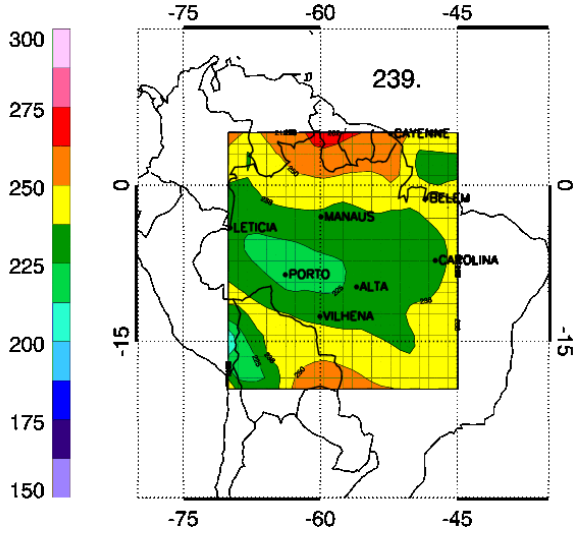



## All DJF days ERA



1) Define convective intensity regimes and methods

**2) Evaluate diurnal cycle shapes by regime**

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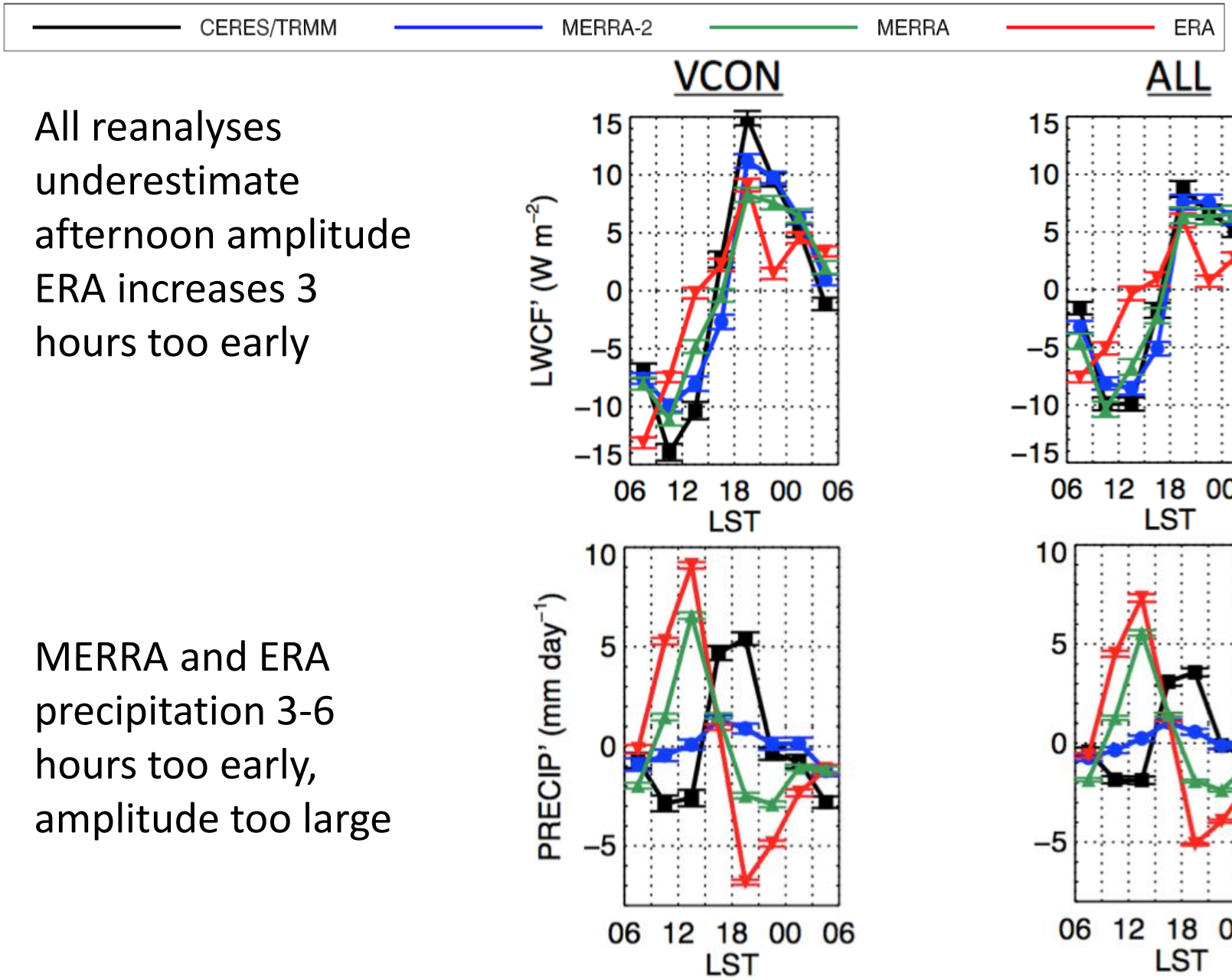
# Domain-averaged DC shapes by regime

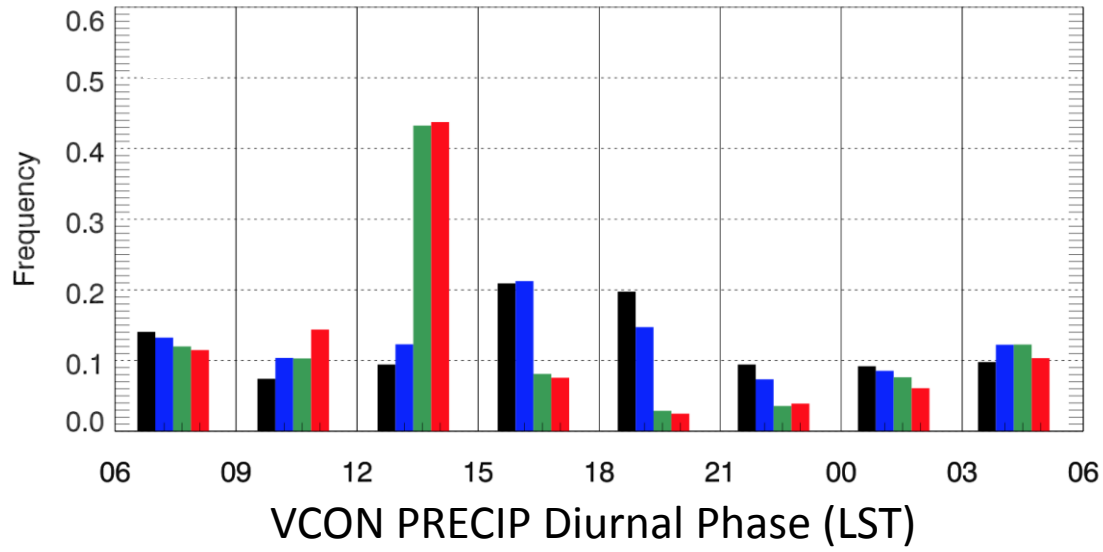



- All reanalyses underestimate afternoon amplitude
- ERA increases 3 hours too early

- MERRA and ERA precipitation 3-6 hours too early, amplitude too large

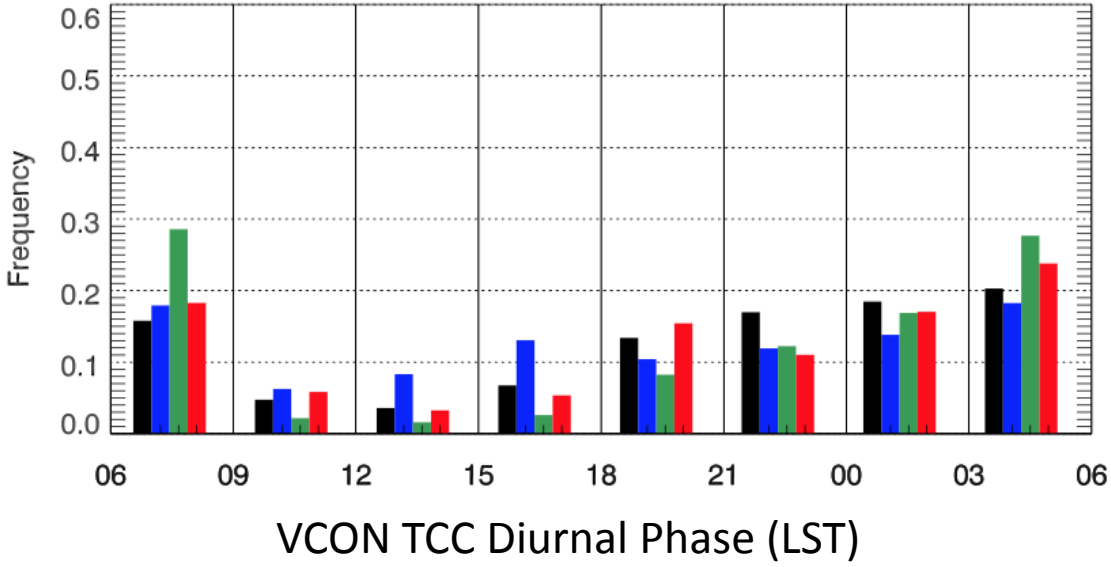
# Histograms of DC statistics are useful

MERRA-2 precip performs much better overall
(observation-corrected)

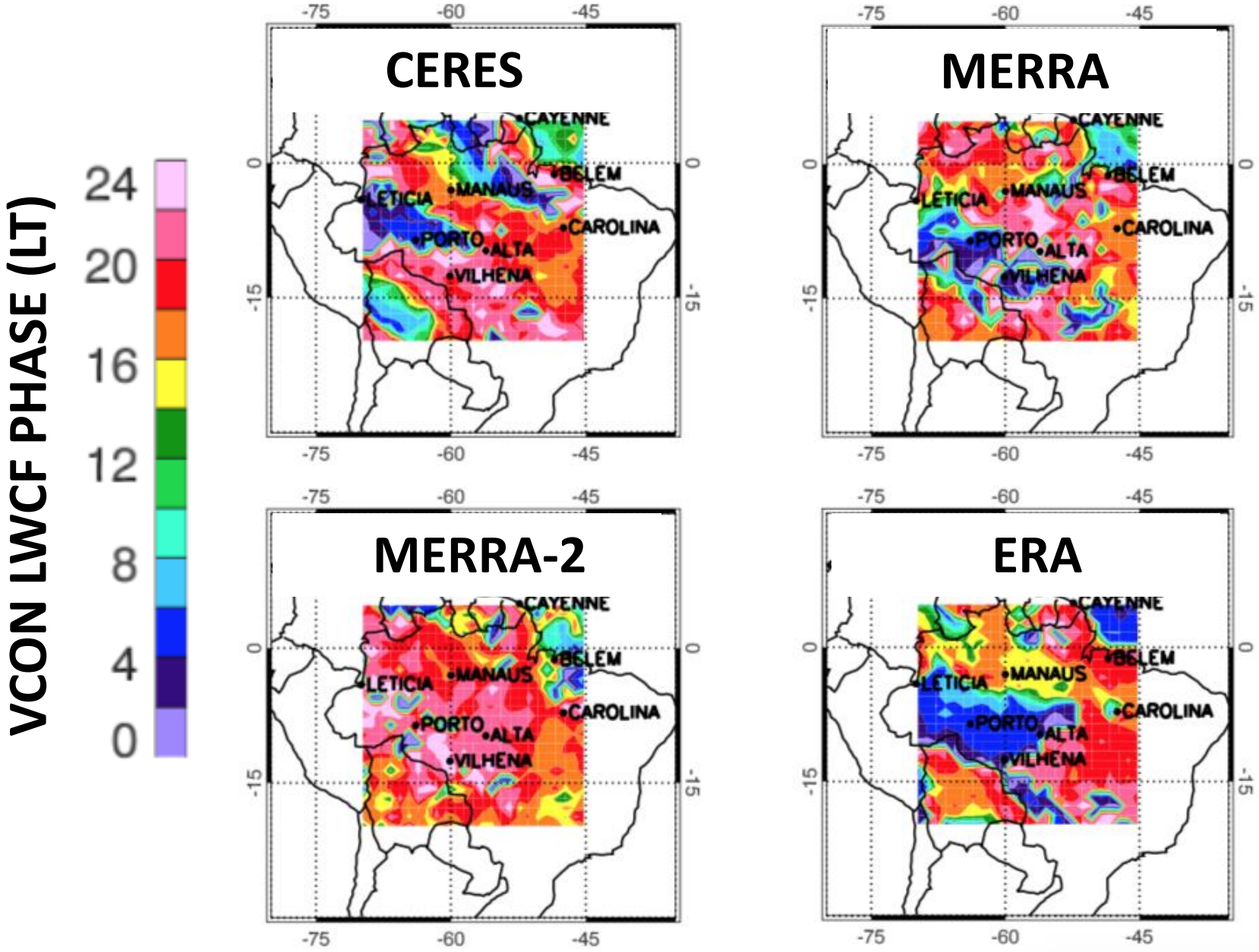



MERRA-2:
TCC phase earlier than CERES

MERRA and ERA:
nocturnal TCC phase



# Spatial plots of DC statistics reveal features



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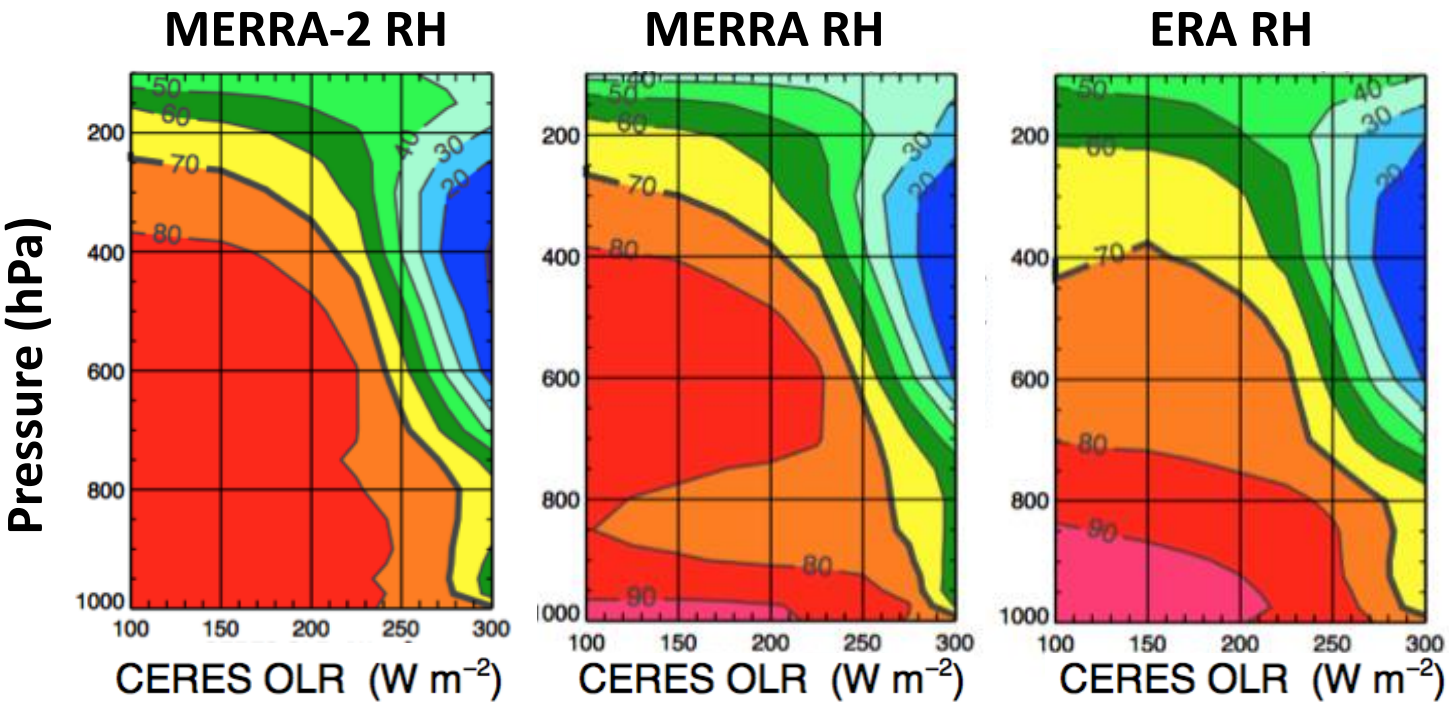
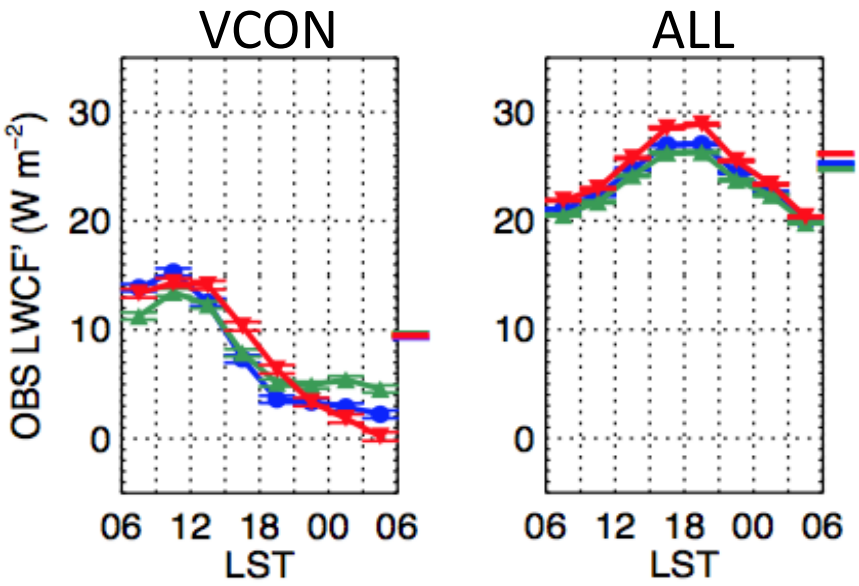
# Comparison of ASVs by model and regime

Model RH vs. Pressure binned by CERES OLR



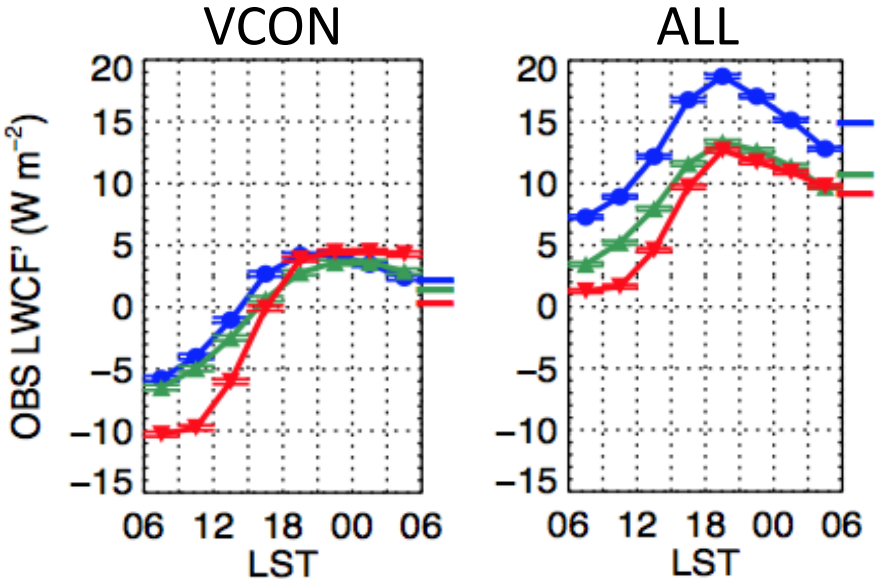
# Domain-averaged regression slopes

## $LWCF'_{DC}$ / $UTH'_{(STD)}$



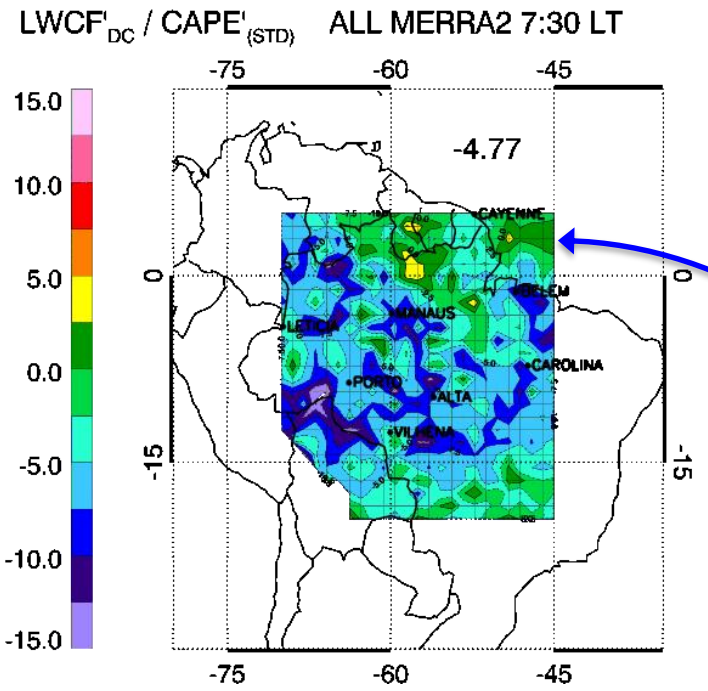

- 1-sigma increase in UTH squishes the morning LWCF 10-15 W m$^{-2}$ higher—shifting LWCF phase earlier in the day

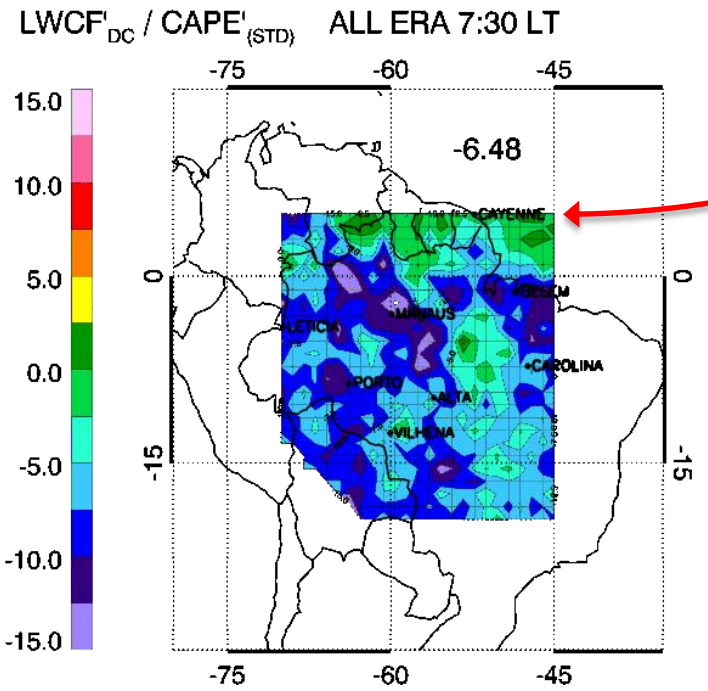
## $LWCF'_{DC}$ / $CAPE'_{(STD)}$



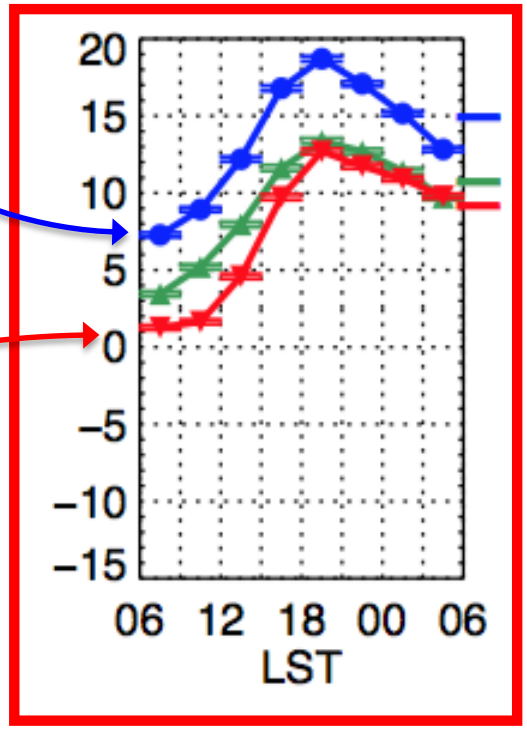

- 1-sigma increase in CAPE stretches LWCF more negative through midafternoon and more positive overnight as the atmosphere generates and "eats up" CAPE

Spatial Regression Slope Diurnal **Anomalies** ($W\ m^{-2}$)




# LWCF' / CAPE'$_{(STD)}$




(Absolute Slopes)

# Summary and future plans

- Even when constrained, reanalyses DCVs show large DC biases
- Total cloud cover and precipitation show **largest biases**
  - **All reanalyses underestimate extreme convection**
  - Observation-corrected precipitation in MERRA-2 better
  - LWCF maximizes too early in ERA, dry bias in MTH/UTH (AIRS?)

- On Very Convective (VCON) days:

**^ CAPE** anomalies >> later LWCF phase, reduced morning LWCF, and increased afternoon LWCF (increased amplitude)

**^ UTH** anomalies >> earlier LWCF phase, **very** increased morning LWCF, and slightly increased afternoon LWCF (reduced amplitude)

- CERES LWCF more sensitive to choice of reanalysis CAPE than UTH

- Regression slope relationships could provide **observationally constrained estimates for model parameterizations** at various scales

**Thanks for listening!**

**Questions/Comments?**